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ISO/TC 102/SC 2/WG 21B
IRON ORES - DETERMINATION OF NICKEL AND/OR CHROMIUM CONTENT BY FLAME ATOMIC ABSORPTION METHOD

R. Sutarno and W.S. Bowman
Extractive Metallurgy Laboratory

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ISO/TC 102/SC 2/WG 21B
IRON ORES - DETERMINATION OF NICKEL AND/OR CHROMIUM CONTENT
BY FLAME ATOMIC ABSORPTION METHOD

STATISTICAL REEVALUATION OF INTERNATIONAL TEST DATA - 1986

by

R. Sutarno* and W. S. Bowman**

SUMMARY

The analytical data resulting from the international test on the determination of Ni and Cr by atomic absorption method conducted by ISO/TC 102/SC 2/WG 21B during the period of 1984-1986 have been statistically reevaluated. Modified regression equations computed from the estimated precision are recommended to express the precision data in the standard document. These equations are:

Ni					
Equation					Minimum Value
r	=	0.0286 X	+	0.0008	-
P	=	0.0892 X	+	0.0011	0.0016
σ_r	=	0.0101 X	+	0.0003	-
σ_L	=	0.0307 X	+	0.0003	0.0005
For 0.02% ≤ X ≤ 0.085%					

Cr					
Equation					Minimum Value
r	=	0.0448 X	+	0.0008	-
P	=	0.0989 X	+	0.0005	0.0012
σ_r	=	0.0157 X	+	0.0003	-
σ_L	=	0.0351 X			-
For 0.003% ≤ X ≤ 0.06%					

where X is the Ni or Cr concentration in the sample, r is the repeatability, P is the permissible tolerance, σ_r is the within-laboratory standard deviation and σ_L is the between-laboratories standard deviation, all expressed in percent. Five samples containing Ni and Cr ranging from 0.002 to 0.08% and 0.003 and 0.05% respectively, were used in this international test. Fifteen laboratories participated in this test.

Key word: ISO, statistics, chemical analysis, iron ore, nickel, chromium.

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*Research Scientist and **Physical Scientist, Physical Chemistry Section, Extractive Metallurgy Laboratory, Mineral Sciences Laboratories, CANMET, Energy, Mines and Resources Canada, Ottawa, Ontario K1A 0G1.

INTRODUCTION

Resolution 1 taken at the 14 th. meeting of ISO/TC 102/SC 2 (Belo Horizonte, October 1988) stated that the subcommittee agreed to accept the recommendation of WG 12B to apply the modified regression equation to express the precision data in the standards documents for trace (minor) elements that are now either in process or under revision. Among this group of elements are nickel and chromium. The analytical data were generated from the international test conducted by WG 21B during the period of 1984-1986. This test involved five samples with Ni and Cr contents ranging from 0.002 to 0.08% and 0.003 to 0.05% respectively. Fifteen laboratories participated in this international test. These data have been previously evaluated using the procedure described in ISO/TC 102/TCR 5[3]. The result of that evaluation has been reported to the convener [1]. The purpose of this reevaluation is to obtain suitable equations for expressing the precision data in the standard document.

STATISTICAL EVALUATION

The analytical data were statistically evaluated by the procedure illustrated schematically in Figure 1. This procedure has been described in document ISO/TC 102/TCR 5[3] with the following modifications:

1. Modification in the estimation of the precision

This part of the modification has been made in order to follow ISO 5725[4].

(a). Grubb's test has replaced Dixon's test to identify the outlying laboratories.

(b). The significance level α for outlier test has been changed from 0.05 to 0.01. Those laboratories that were previously identified as outliers with significance level of α between 0.01 and 0.05 are identified as stragglers. These data are used to compute the means and precision.

2. Computation of the regression equations

2.1 Reasons for modification

The precision data of a standard method are measured experimentally by international test during the stage B of the development of the standard methods. In the past these data were presented in the form of a precision table, a stepwise table . This method of presentation was considered inadequate because there is a good chance that the content of the element of interest in any sample will fall between the steps. For this reason, it was discontinued, and replaced by equations expressing the functional relation between the element content and the precision. These equations were computed by the least squares method from the observed data. This change of presentation does solve the problem of discontinuity experienced by the precision table; but, it also creates new problems.

(1). For practical reasons most precision experiments are limited to using a small number of test samples (in this case 5); for this reason, only linear regression equations can be derived from the results. This linear function may or may not be the correct function for expressing the precision for a particular method. Furthermore, in many cases, the range of concentration covered is too wide to justify chemically the use of the same equation i.e. that the same chemical behavior occurs throughout the range of concentration. For minor (trace) elements, the range is usually very wide. It is not unusual that, for a given precision experiment, the highest concentration is several orders of magnitudes higher than the lowest.

(2). The other problem is the problem of weighting the experimental points. Intuitively, the error of the precision estimate is proportional to the level of concentration. Thus an unweighted regression equation automatically would give too much weight to the points at higher concentration level. As a result, sometimes the regression lines have unrealistic slopes and intercepts (even negative). Thus the precision computed from the regression lines, particularly at lower concentration levels, does sometimes differ from the experimental value by some significant quantity.

(3). In many cases, the space between levels of test samples for the precision experiment is uneven. This magnifies the above problem.

For these reasons, ISO/TC 102/SC 2/WG 12B has decided to investigate the possibility of using a modified form of the regression equation for expressing the precision of analytical methods for minor elements. The finding was discussed at the WG 12B meeting held in conjunction with the 14 th. meeting of the subcommittee. It was agreed that the modified regression equation will be used to express the precision data in the standard methods for trace (minor) elements).

2.2. Modified regression equation

The linear regression equations are computed by the least squares method from the precision estimated from the analysis of variance (ANOVA)[2]. The expected value of the precision y(1) at the lowest level of concentration, x(1), was computed. There are various possibilities:

(1). If y(1) is equal to the observed value, z(1), use the regression equation unmodified. The term "equal" means within 10%.

(2) If y(1) is less than z(1), identify the minimum observed value of the precision, z(min). The unmodified regression equation is then used to express the precision with a condition that the minimum value of the precision will be z(min).

(3) If y(1) is greater than z(1), compute a new regression line by a modified least squares method. Force the line to pass a fixed intercept. There are two possibilities to be considered:

(a) if the observed value of the precision of the second lowest level, z(2) is smaller that z(1), compute the average of z(1) and z(2), and use this average as the intercept.

(b) if z(2) is greater than z(1), use the intercept of the straight line connecting z(1) and z(2) with the precision axis as the new intercept.

Where:

x(1) - the lowest value of x (concentration).
y(1) - the expected value of precision at x(1) (computed from the original regression equations).
z(1) - the observed value (estimated from ANOVA) of precision at x(1).
z(min) - the minimum observed value of all levels (usually either at x(1) or x(2)).

The detailed results of computations are presented in Appendix A and summarized in Tables 1, 2, 3 and 4.

RESULTS AND DISCUSSION

Tables 1 show the precision estimated from the data using the modified procedure. These estimates differ slightly from the estimates previously reported[1]. The difference is caused by the slight difference in the number of outliers. Some of the laboratories identified as outliers by the old procedure, become stragglers by the new procedure due to the change in the significance level α used (Tables 2). For this reason, the original regression equations computed shown in the left hand side of Tables 4 differ slightly from the previously reported equations[1]. Table 4.Ni shows that in the case of Ni the revised equations are the same as the original equations with minimum values for P and σ_L. Table 3.Cr shows that the revised equations for σ_r and r are in worse agreement with the observed values than the original equation. For this reason, the modified regression equation for σ_r can not be recommended. This deviates some what from the decision taken at the 14 th meeting. Also the revised equation for σ_L is presented without a minimum value as the estimated value of σ_L for the second lowest level of Cr is zero (between-laboratories mean square is less than the within-laboratory mean square). This situation appears to indicate a difficulty with the modified scheme. However it is not as bad as it might appear, since σ_L is never used by itself; it is always used in combination with σ_r as in estimating the permissible tolerance, P. Taking these situations into account, the equations recommended for use in the standard document are bracketed at the end of Tables 4 and graphically illustrated in Figures 2.

In view of the difficulties encountered here with the repeatability r (and σ_r), for chromium, the procedure given above for obtaining modified expression should be applied with caution. Also it is recommended that item (3) of the procedure should be subject to reconsideration.

REFERENCES

1. "ISO/TC 102/SC 2/WG 21B - Iron ores - Determination of nickel and/or chromium content by flame atomic absorption method - Statistical analysis of international test data - 1986", R. Sutarno and W. S. Bowman, CANMET MSL 86-128 (IR), October 1986.

2. "ISO/DP 9685 - Iron ores - Determination of nickel and/or chromium contents - Flame atomic absorption spectrometric method (Second draft proposal)", ISO/TC 102/SC 2 N894E, 1988-01-22.

3. "Procedure for statistical evaluation of analytical data resulting from international tests", ISO/TC 102/TCR 5, 1985-06-11.

4. "Accuracy (trueness and precision) of measurement methods and results", ISO 5725, Under revision.

Table 1.Ni

ISO/TC 102/SC 2/WG 21B 1986 --- Ni/Cr BY FLAME AAS METHOD

SUMMARY OF PRECISION FOR ALL SAMPLES

EL	SAMPLE	K_o	K	N_o	N	MEAN(X)	r	P	σ_r	σ_L	σ_L/σ_r
Ni	79-6	14	14	56	56	0.0020	0.0009	0.0016	0.00031	0.00051	1.64
Ni	76-17	14	13	56	52	0.0487	0.0021	0.0029	0.00075	0.00088	1.16
Ni	81-6	14	13	56	52	0.0168	0.0014	0.0024	0.00048	0.00078	1.62
Ni	85-13	14	14	56	56	0.0108	0.0012	0.0031	0.00041	0.00106	2.59
Ni	85-14	14	14	56	56	0.0843	0.0033	0.0100	0.00116	0.00343	2.95

Table 2.Ni

ISO/TC 102/SC 2/WG 21B 1986 --- Ni/Cr BY FLAME AAS METHOD

LIST OF OUTLIERS

EL	SAMPLE	COCHRAN (PRECISION)	GRUBBS (ACCURACY)	LAB HAS ONLY ONE RESULT	INDIVIDUAL OUTLYING RESULT (DIXON)
Ni	79-6	(JP 1)	-	-	-
Ni	76-17	IT 2	-	-	-
		(FR 2)	-	-	-
Ni	81-6	(IT 2)	IT 1	-	-
Ni	85-13	-	-	-	-
Ni	85-14	-	-	-	-

STRAGGLERS ARE LISTED IN PARENTHESES

Table 3.Ni

ISO/TC 102/SC 2/WG 21B 1986 --- Ni/Cr BY FLAME AAS METHOD

OBSERVED AND PREDICTED VALUES OF PRECISION

MEAN(X)	OBS ()	PRED ()	% DIFF	REVISED ()	% DIFF*
		r			
0.0020	0.0009	0.0009	0.84	0.0009	0.84
0.0108	0.0012	0.0011	-0.97	0.0011	-0.97
0.0168	0.0014	0.0013	-3.46	0.0013	-3.46
0.0487	0.0021	0.0022	4.47	0.0022	4.47
0.0843	0.0033	0.0032	-1.35	0.0032	-1.35
		P			
0.0020	0.0016	0.0013	-19.87	0.0016	0.00
0.0108	0.0031	0.0020	-33.90	0.0020	-33.90
0.0168	0.0024	0.0026	7.97	0.0026	7.97
0.0487	0.0029	0.0054	87.33	0.0054	87.33
0.0843	0.0100	0.0086	-13.63	0.0086	-13.63
NOTE: - MINIMUM REVISED P IS 0.0016					
		σ_r			
0.0020	0.0003	0.0003	1.42	0.0003	1.42
0.0108	0.0004	0.0004	-1.75	0.0004	-1.75
0.0168	0.0005	0.0005	-3.32	0.0005	-3.32
0.0487	0.0008	0.0008	4.65	0.0008	4.65
0.0843	0.0012	0.0011	-1.39	0.0011	-1.39
		σ_L			
0.0020	0.0005	0.0004	-22.54	0.0005	0.00
0.0108	0.0011	0.0007	-37.32	0.0007	-37.32
0.0168	0.0008	0.0009	9.09	0.0009	9.09
0.0487	0.0009	0.0018	107.75	0.0018	107.75
0.0843	0.0034	0.0029	-14.83	0.0029	-14.83
NOTE: - MINIMUM REVISED σ_L IS 0.0005					

*% DIFF (ABOVE) IS DEFINED AS 100 * (Y-YOBS) / YOBS
WHERE Y IS THE PREDICTED OR REVISED PRECISION

Table 4.Ni

ISO/TC 102/SC 2/WG 21B 1986 --- Ni/Cr BY FLAME AAS METHOD

REGRESSION EQUATIONS

Original				Modified			
			Corr. Coeff				
r = 0.0286 X +	0.0008	0.9982		r = 0.0286 X +	0.0008		
P = 0.0892 X +	0.0011	0.8910		P = 0.0892 X +	0.0011		
σ_r = 0.0101 X +	0.0003	0.9981		σ_r = 0.0101 X +	0.0003		
σ_L = 0.0307 X +	0.0003	0.8744		σ_L = 0.0307 X +	0.0003		

EQUATIONS TO BE USED FOR THE STANDARD METHOD DOCUMENT

Ni

Equation	Min. Value
r = 0.0286 X + 0.0008	-
P = 0.0892 X + 0.0011	0.0016
σ_r = 0.0101 X + 0.0003	-
σ_L = 0.0307 X + 0.0003	0.0005

For $0.002\% \leq X \leq 0.085\%$

Table 1.Cr

ISO/TC 102/SC 2/WG 21B 1986 --- Ni/Cr BY FLAME AAS METHOD

SUMMARY OF PRECISION FOR ALL SAMPLES

EL	SAMPLE	K_o	K	N_o	N	MEAN(X)	r	P	σ_r	σ_L	σ_L/σ_r
Cr	79-6	15	14	60	56	0.0035	0.0007	0.0012	0.00023	0.00039	1.70
Cr	76-17	15	14	60	56	0.0115	0.0019	0.0014	0.00068	0.00000	0.00
Cr	81-6	15	15	60	60	0.0559	0.0033	0.0061	0.00115	0.00199	1.73
Cr	85-13	15	15	60	60	0.0164	0.0012	0.0018	0.00042	0.00055	1.29
Cr	85-14	15	15	60	60	0.0186	0.0017	0.0026	0.00059	0.00081	1.36

Table 2.Cr

ISO/TC 102/SC 2/WG 21B 1986 --- Ni/Cr BY FLAME AAS METHOD

LIST OF OUTLIERS

EL	SAMPLE	COCHRAN (PRECISION)	GRUBBS (ACCURACY)	LAB HAS ONLY ONE RESULT	INDIVIDUAL OUTLYING RESULT (DIXON)
Cr	79-6	IT 1	-	-	-
Cr	76-17	(SU 2)	AU 1	-	-
		(SU 3)	-	-	-
Cr	81-6	-	-	-	-
Cr	85-13	(IT 2)	-	-	-
Cr	85-14	(IT 2)	-	-	-

STRAGGLERS ARE LISTED IN PARENTHESES

Table 3.Cr

ISO/TC 102/SC 2/WG 21B 1986 --- Ni/Cr BY FLAME AAS METHOD

OBSERVED AND PREDICTED VALUE OF PRECISION

MEAN(X)	OBS ()	PRED ()	% DIFF	REVISED ()	% DIFF*
			r		
0.0035	0.0007	0.0010	46.81	0.0003	-51.64
0.0115	0.0019	0.0013	-31.66	0.0008	-56.95
0.0164	0.0012	0.0015	27.33	0.0011	-5.36
0.0186	0.0017	0.0016	-3.08	0.0013	-23.85
0.0559	0.0033	0.0033	0.84	0.0037	12.21
			P		
0.0035	0.0012	0.0009	-28.79	0.0012	0.00
0.0115	0.0014	0.0016	21.82	0.0016	21.82
0.0164	0.0018	0.0021	19.83	0.0021	19.83
0.0186	0.0026	0.0023	-9.20	0.0023	-9.20
0.0559	0.0061	0.0060	-1.03	0.0060	-1.03
NOTE: - MINIMUM REVISED P IS 0.0012					
			σ_r		
0.0035	0.0002	0.0003	46.48	0.0001	-51.97
0.0115	0.0007	0.0005	-31.99	0.0003	-57.25
0.0164	0.0004	0.0005	28.14	0.0004	-4.90
0.0186	0.0006	0.0006	-2.81	0.0004	-23.74
0.0559	0.0012	0.0012	0.79	0.0013	12.22
			σ_L		
0.0035	0.0004	0.0001	-66.75	0.0001	-66.75
0.0115	0.0000	0.0004	-	0.0004	-
0.0164	0.0006	0.0006	5.25	0.0006	5.25
0.0186	0.0008	0.0007	-18.84	0.0007	-18.84
0.0559	0.0020	0.0020	-1.29	0.0020	-1.29

*% DIFF (ABOVE) IS DEFINED AS 100 * (Y-YOBS) / YOBS
WHERE Y IS THE PREDICTED OR REVISED PRECISION

Table 4.Cr

ISO/TC 102/SC 2/WG 21B 1986 --- Ni/Cr BY FLAME AAS METHOD

REGRESSION EQUATIONS

Original				Modified			
			Corr. Coeff				
r = 0.0448 X +	0.0008	0.9227		r = 0.0641 X +	0.0001		
P = 0.0989 X +	0.0005	0.9880		P = 0.0989 X +	0.0005		
σ_r = 0.0157 X +	0.0003	0.9203		σ_r = 0.0226 X +	0.0000		
σ_L = 0.0351 X +	0.0000	0.9410		σ_L = 0.0351 X +	0.0000		

EQUATIONS TO BE USED FOR THE STANDARD METHOD DOCUMENT

Cr

Equation	Min. Value
r = 0.0448 X + 0.0008	-
P = 0.0989 X + 0.0005	0.0012
σ_r = 0.0157 X + 0.0003	-
σ_L = 0.0351 X + 0.0000	-

For $0.003\% \leq X \leq 0.06\%$

ABBREVIATIONS USED IN THIS REPORT

AU - Australia
FR - France
IT - Italy
JP - Japan
NL - Netherlands
SU - Soviet Union

K_O - Total number of participating laboratories.
K - Number of participating laboratories used for computation of precision.
N_O - Total number of analytical results.
N - Number of analytical results used for computation of precision.
X = MEAN(X) - Overall mean of Ni or Cr concentration in the sample in %.
r - Repeatability in % Ni or Cr.
P - Permissible tolerance in % Ni or Cr.
σ_r - Repeatability standard deviation in % Ni or Cr.
σ_L - Between-laboratories standard deviation in % Ni or Cr.
OBS () - Observed values of precision estimated from ANOVA.
PRED () - Predicted values of precision computed from the original equation.
%DIFF - The difference of either the PRED () or REVISED () and OBS () expressed as percentage of OBS ()
REVISED () - Predicted values of precision computed from the modified regression equations.

$$P = 2.83\ [\sigma_L + \sigma_r/2]^{1/2}$$

$$r = 2.83\ \sigma_r$$

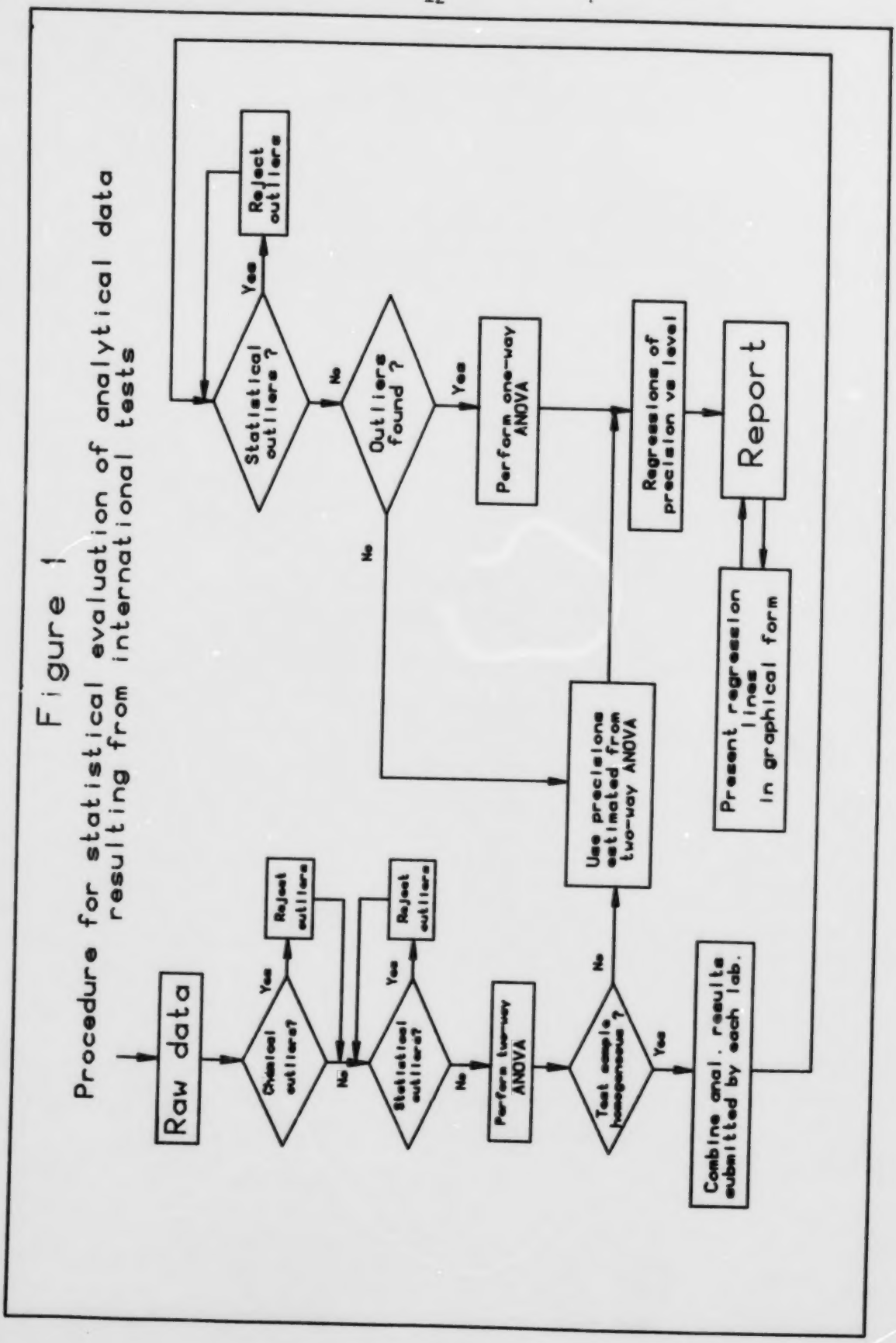
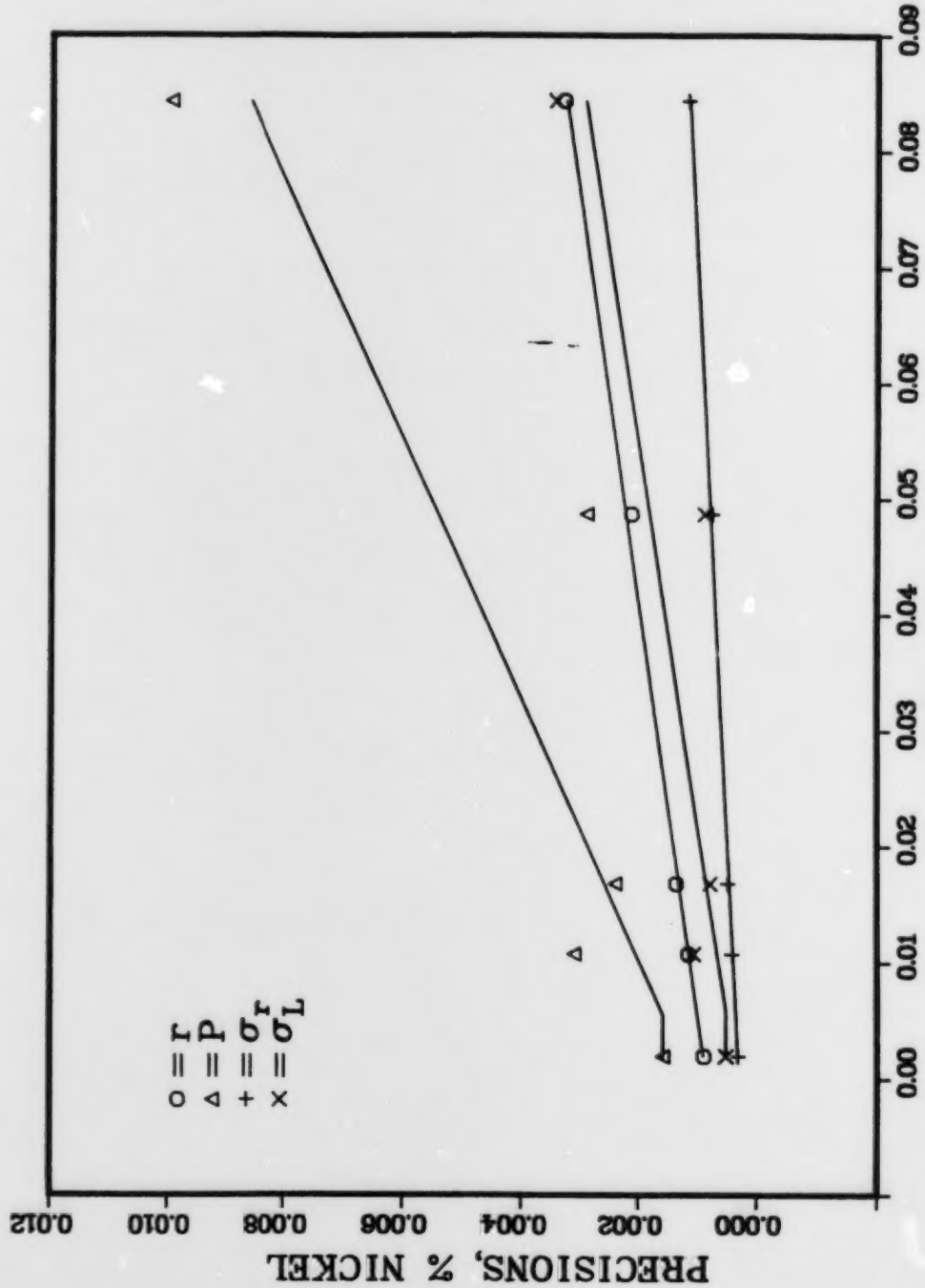


Figure 1

Procedure for statistical evaluation of analytical data resulting from international tests


PRECISIONS, % NICKEL
0.000
0.002
0.004
0.006
0.008
0.010
0.012
GRAND MEANS, % NICKEL
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
o = r
Δ = P
+ = σr
× = σL
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Figue 2. Ni

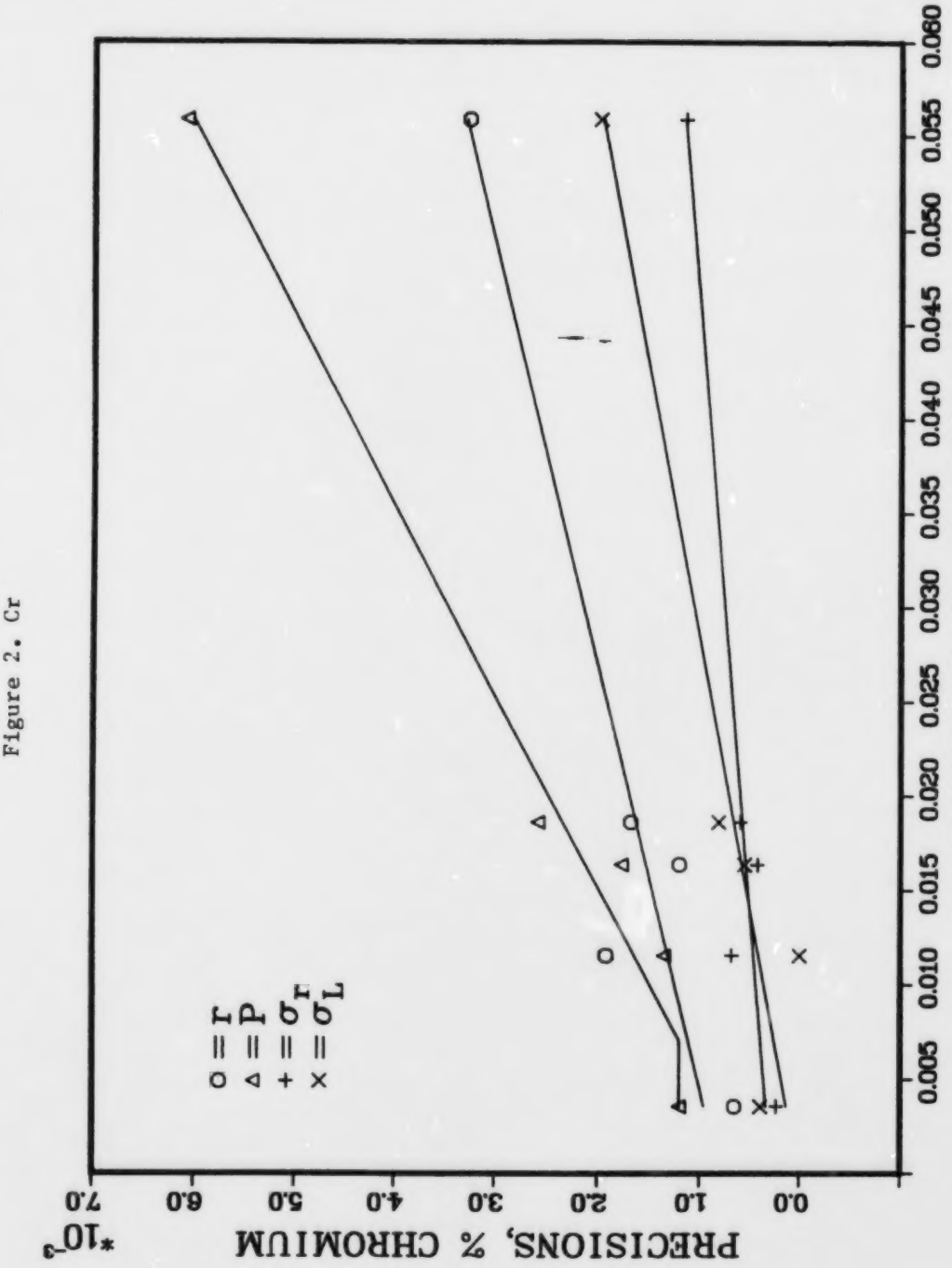
PRECISIONS, % CHROMIUM
*10⁻³
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0.040
0.045
0.050
0.055
0.060
GRAND MEANS, % CHROMIUM
o = r
Δ = R
+ = σr
× = σL
ISO/TC 102/SC 2/WG 21B 1986 —— NI/CR BY FLAME AAS METHOD

Figure 2. Cr

ISO/TC 102/SC 2/WG 21B
IRON ORES - DETERMINATION OF NICKEL AND/OR CHROMIUM CONTENT
BY FLAME ATOMIC ABSORPTION METHOD

STATISTICAL REEVALUATION OF INTERNATIONAL TEST DATA - 1986

Appendix A. Ni

Detailed Computation of Analytical Data

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 79-6 NICKEL WT %

LABORATORY NO.	COUNTRY	BOTTLE NO.	ANALYTICAL RESULTS NICKEL		LAB MEAN	LAB VARIANCE
1	AU 1	1	.0012	.0016	.00124	.5720E-07
		2	.0010	.0013		
2	AU 2	1	.0013	.0013	.00163	.1558E-06
		2	.0021	.0018		
3	FR 1	1	.0018	.0024	.00205	.1233E-06
		2	.0017	.0023		
4	FR 2	1	.0024	.0021	.00208	.5583E-07
		2	.0019	.0019		
5	IT 1	1	.0020	.0025	.00265	.2567E-06
		2	.0030	.0031		
6	IT 2	1	.0028	.0031	.00290	.1000E-06
		2	.0025	.0032		
7	JP 1	1	.0012	.0012	.00175	.4100E-06
		2	.0024	.0022		
8	JP 2	1	.0019	.0018	.00180	.6667E-08
		2	.0018	.0017		
9	JP 3	1	.0016	.0017	.00165	.3333E-08
		2	.0016	.0017		
10	JP 5	1	.0016	.0015	.00155	.3333E-08
		2	.0016	.0015		
11	JP 6	1	.0016	.0015	.00153	.2500E-08
		2	.0015	.0015		
12	NL 1	1	.0018	.0019	.00170	.4667E-07
		2	.0017	.0014		
13	SU 1	1	.0028	.0031	.00300	.2000E-07
		2	.0030	.0031		
14	SU 3	1	.0018	.0025	.00215	.1233E-06
		2	.0019	.0024		

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 79-6 NICKEL WT %

COCHRAN'S TEST FOR BOTTLE VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

DOORNBOS' TEST FOR BOTTLE MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR TWO-WAY ANOVA

AU 2	ZERO WITHIN-BOTTLE VARIANCE
FR 2	ZERO WITHIN-BOTTLE VARIANCE
JP 1	ZERO WITHIN-BOTTLE VARIANCE
JP 6	ZERO WITHIN-BOTTLE VARIANCE

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 79-6 NICKEL WT %

TWO-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	9	.12969960E-04	.14411067E-05
BETWEEN BOTTLES	10	.83760000E-06	.83760000E-07
WITHIN BOTTLES	20	.13840000E-05	.69200000E-07
TOTAL	39	.15191560E-04	

F-CALC = 1.210 F-CRIT(.95;10,20) = 2.348

TEST SAMPLE IS HOMOGENEOUS

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 79-6 NICKEL WT %

COCHRAN'S TEST FOR LABORATORY VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

JP 1 C-CALC = .300 C-CRIT(4,14) = .291

GRUBBS' TEST FOR LABORATORY MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR ONE-WAY ANOVA

ALL RESULTS WERE USED EXCEPT INDIVIDUAL REPLICATES LISTED BELOW

LIST OF INDIVIDUAL OUTLIERS DETECTED BY DIXON'S TEST WITHIN-LABORATORIES

NONE REJECTED

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 79-6 NICKEL WT %

ONE-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	13	.14865836E-04	.11435258E-05
WITHIN LABS	42	.40941000E-05	.97478571E-07
TOTAL	55	.18959936E-04	

REPEATABILITY VARIANCE	.97478571E-07
REPEATABILITY STD. DEV.	.00031222
BETWEEN-LABORATORIES VARIANCE	.26151181E-06
BETWEEN-LABORATORIES STD. DEV.	.00051138
REPEATABILITY	.00088357
PERMISSIBLE TOLERANCE BETWEEN LABS	.00157632
GRAND MEAN	.00197607
VARIANCE OF THE GRAND MEAN	.20420104E-07

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 76-17 NICKEL WT %

LABORATORY NO.	COUNTRY	BOTTLE NO.	ANALYTICAL RESULTS NICKEL		LAB MEAN	LAB VARIANCE
1	AU 1	1	.0467	.0485	.04717	.7762E-06
		2	.0470	.0466		
2	AU 2	1	.0492	.0474	.04798	.8158E-06
		2	.0481	.0472		
3	FR 1	1	.0494	.0495	.04933	.2250E-07
		2	.0492	.0492		
4	FR 2	1	.0498	.0488	.04800	.2427E-05
		2	.0466	.0468		
5	IT 1	1	.0500	.0505	.04975	.4167E-06
		2	.0490	.0495		
6	IT 2	1	.0465	.0505	.04775	.4917E-05
		2	.0485	.0455		
7	JP 1	1	.0485	.0485	.04873	.1092E-06
		2	.0492	.0487		
8	JP 2	1	.0505	.0504	.04955	.1363E-05
		2	.0493	.0480		
9	JP 3	1	.0484	.0491	.04873	.2492E-06
		2	.0482	.0492		
10	JP 5	1	.0497	.0505	.05018	.1558E-06
		2	.0500	.0505		
11	JP 6	1	.0475	.0483	.04770	.2667E-06
		2	.0471	.0479		
12	NL 1	1	.0483	.0483	.04860	.1267E-06
		2	.0488	.0490		
13	SU 1	1	.0503	.0493	.04975	.3367E-06
		2	.0502	.0492		
14	SU 3	1	.0472	.0473	.04768	.3025E-06
		2	.0478	.0484		

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 76-17 NICKEL WT %

COCHRAN'S TEST FOR BOTTLE VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

IT 2 BOTTLE- 1 C-CALC = .384 C-CRIT(2,22) = .365

DOORNBOS' TEST FOR BOTTLE MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR TWO-WAY ANOVA

FR 1	ZERO WITHIN-BOTTLE VARIANCE
JP 1	ZERO WITHIN-BOTTLE VARIANCE
NL 1	ZERO WITHIN-BOTTLE VARIANCE

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 76-17 NICKEL WT %

TWO-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	10	.44913000E-04	.44913000E-05
BETWEEN BOTTLES	11	.15246100E-04	.13860091E-05
WITHIN BOTTLES	22	.20832400E-04	.94692727E-06
TOTAL	43	.80991500E-04	

F-CALC = 1.464 F-CRIT(.95;11,22) = 2.259

TEST SAMPLE IS HOMOGENEOUS

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 76-17 NICKEL WT %

COCHRAN'S TEST FOR LABORATORY VARIANCE (ALPHA=.01)

IT 2 C-CALC = .400 C-CRIT(4,14) = .350

STRAGGLERS (ALPHA =.05)

FR 2 C-CALC = .329 C-CRIT(4,13) = .307

GRUBBS' TEST FOR LABORATORY MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR ONE-WAY ANOVA

IT 2 COCHRAN'S TEST FOR LABORATORY VARIANCE

LIST OF INDIVIDUAL OUTLIERS DETECTED BY DIXON'S TEST WITHIN-LABORATORIES

NONE REJECTED

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 76-17 NICKEL WT %

ONE-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	12	.43709831E-04	.36424859E-05
WITHIN LABS	39	.22103500E-04	.56675641E-06
TOTAL	51	.65813331E-04	

REPEATABILITY VARIANCE	.56675641E-06
REPEATABILITY STD. DEV.	.00075283
BETWEEN-LABORATORIES VARIANCE	.76893237E-06
BETWEEN-LABORATORIES STD. DEV.	.00087689
REPEATABILITY	.00213052
PERMISSIBLE TOLERANCE BETWEEN LABS	.00290308
GRAND MEAN	.04870115
VARIANCE OF THE GRAND MEAN	.70047806E-07

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 81-6 NICKEL WT %

LABORATORY NO.	COUNTRY	BOTTLE NO.	ANALYTICAL RESULTS NICKEL		LAB MEAN	LAB VARIANCE
1	AU 1	1	.0154	.0155	.01565	.1918E-06
		2	.0163	.0154		
2	AU 2	1	.0159	.0159	.01595	.3333E-08
		2	.0160	.0160		
3	FR 1	1	.0175	.0178	.01760	.3333E-07
		2	.0174	.0177		
4	FR 2	1	.0166	.0164	.01628	.1158E-06
		2	.0158	.0163		
5	IT 1	1	.0225	.0220	.02188	.3958E-06
		2	.0220	.0210		
6	IT 2	1	.0170	.0195	.01800	.1167E-05
		2	.0175	.0180		
7	JP 1	1	.0165	.0164	.01673	.1025E-06
		2	.0170	.0170		
8	JP 2	1	.0169	.0169	.01685	.3000E-07
		2	.0170	.0166		
9	JP 3	1	.0166	.0169	.01678	.2250E-07
		2	.0169	.0167		
10	JP 5	1	.0170	.0167	.01670	.8667E-07
		2	.0168	.0163		
11	JP 6	1	.0163	.0159	.01615	.9000E-07
		2	.0165	.0159		
12	NL 1	1	.0164	.0165	.01650	.8667E-07
		2	.0169	.0162		
13	SU 1	1	.0181	.0189	.01848	.5892E-06
		2	.0176	.0193		
14	SU 3	1	.0166	.0181	.01725	.4700E-06
		2	.0168	.0175		

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 81-6 NICKEL WT %

COCHRAN'S TEST FOR BOTTLE VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

IT 2 BOTTLE- 1 C-CALC = .371 C-CRIT(2,22) = .365

DOORNBOS' TEST FOR BOTTLE MEANS (ALPHA=.01)

IT 1 BOTTLE- 1 T-CALC = 4.293 T-CRIT(.00036,26) = 4.103

IT 1 BOTTLE- 2 T-CALC = 5.646 T-CRIT(.00037,25) = 4.113

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR TWO-WAY ANOVA

AU 2	ZERO WITHIN-BOTTLE VARIANCE
IT 1	DOORNBOS' TEST FOR BOTTLE MEANS
JP 1	ZERO WITHIN-BOTTLE VARIANCE
JP 2	ZERO WITHIN-BOTTLE VARIANCE

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 81-6 NICKEL WT %

TWO-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	9	.28132840E-04	.31258711E-05
BETWEEN BOTTLES	10	.76960000E-06	.76960000E-07
WITHIN BOTTLES	20	.77884000E-05	.38942000E-06
TOTAL	39	.36690840E-04	

F-CALC = .198 F-CRIT(.95;10,20) = 2.348

TEST SAMPLE IS HOMOGENEOUS

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 81-6 NICKEL WT %

COCHRAN'S TEST FOR LABORATORY VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

IT 2 C-CALC = .345 C-CRIT(4,14) = .291

GRUBBS' TEST FOR LABORATORY MEANS (ALPHA=.01)

IT 1 T = 3.005 T-CRIT(14) = 2.755

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR ONE-WAY ANOVA

IT 1 GRUBBS' TEST FOR LABORATORY MEANS

LIST OF INDIVIDUAL OUTLIERS DETECTED BY DIXON'S TEST WITHIN-LABORATORIES

NONE REJECTED

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 81-6 NICKEL WT %

ONE-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	12	.31730708E-04	.26442256E-05
WITHIN LABS	39	.89655000E-05	.22988462E-06
TOTAL	51	.40696208E-04	

REPEATABILITY VARIANCE	.22988462E-06
REPEATABILITY STD. DEV.	.00047946
BETWEEN-LABORATORIES VARIANCE	.60358526E-06
BETWEEN-LABORATORIES STD. DEV.	.00077691
REPEATABILITY	.00135688
PERMISSIBLE TOLERANCE BETWEEN LABS	.00239888
GRAND MEAN	.01683808
VARIANCE OF THE GRAND MEAN	.50850493E-07

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-13 NICKEL WT %

LABORATORY NO.	COUNTRY	BOTTLE NO.	ANALYTICAL RESULTS NICKEL		LAB MEAN	LAB VARIANCE
1	AU 1	1	.0095	.0093	.00935	.1851E-06
		2	.0098	.0088		
2	AU 2	1	.0092	.0097	.00940	.6000E-07
		2	.0092	.0095		
3	FR 1	1	.0125	.0130	.01255	.1100E-06
		2	.0122	.0125		
4	FR 2	1	.0103	.0105	.01043	.8917E-07
		2	.0101	.0108		
5	IT 1	1	.0125	.0120	.01238	.2292E-06
		2	.0120	.0130		
6	IT 2	1	.0125	.0130	.01263	.2292E-06
		2	.0120	.0130		
7	JP 1	1	.0100	.0102	.01018	.5583E-07
		2	.0100	.0105		
8	JP 2	1	.0102	.0104	.01033	.4917E-07
		2	.0101	.0106		
9	JP 3	1	.0103	.0103	.01035	.1000E-07
		2	.0103	.0105		
10	JP 5	1	.0112	.0104	.01070	.2267E-06
		2	.0110	.0102		
11	JP 6	1	.0106	.0096	.01015	.4967E-06
		2	.0109	.0095		
12	NL 1	1	.0103	.0102	.01030	.6667E-08
		2	.0104	.0103		
13	SU 1	1	.0118	.0121	.01143	.4892E-06
		2	.0105	.0113		
14	SU 3	1	.0106	.0105	.01050	.8667E-07
		2	.0108	.0101		

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-13 NICKEL WT %

COCHRAN'S TEST FOR BOTTLE VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

DOORNBOS' TEST FOR BOTTLE MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR TWO-WAY ANOVA

JP 3 ZERO WITHIN-BOTTLE VARIANCE

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-13 NICKEL WT %

TWO-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	12	.59450792E-04	.49542327E-05
BETWEEN BOTTLES	13	.15160250E-05	.11661731E-06
WITHIN BOTTLES	26	.54242500E-05	.20862500E-06
TOTAL	51	.66391067E-04	

F-CALC = .559 F-CRIT(.95;13,26) = 2.119

TEST SAMPLE IS HOMOGENEOUS

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-13 NICKEL WT %

COCHRAN'S TEST FOR LABORATORY VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

GRUBBS' TEST FOR LABORATORY MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR ONE-WAY ANOVA

ALL RESULTS WERE USED EXCEPT INDIVIDUAL REPLICATES LISTED BELOW

LIST OF INDIVIDUAL OUTLIERS DETECTED BY DIXON'S TEST WITHIN-LABORATORIES

NONE REJECTED

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-13 NICKEL WT %

ONE-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	13	.60176809E-04	.46289853E-05
WITHIN LABS	42	.69702750E-05	.16595893E-06
TOTAL	55	.67147084E-04	

REPEATABILITY VARIANCE	.16595893E-06
REPEATABILITY STD. DEV.	.00040738
BETWEEN-LABORATORIES VARIANCE	.11157566E-05
BETWEEN-LABORATORIES STD. DEV.	.00105629
REPEATABILITY	.00115289
PERMISSIBLE TOLERANCE BETWEEN LABS	.00309848
GRAND MEAN	.01076054
VARIANCE OF THE GRAND MEAN	.82660452E-07

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-14 NICKEL WT %

LABORATORY NO.	COUNTRY	BOTTLE NO.	ANALYTICAL RESULTS NICKEL		LAB MEAN	LAB VARIANCE
1	AU 1	1	.0854	.0852	.08380	.3313E-05
		2	.0830	.0816		
2	AU 2	1	.0872	.0852	.08600	.7200E-06
		2	.0858	.0858		
3	FR 1	1	.0780	.0775	.07775	.8333E-07
		2	.0780	.0775		
4	FR 2	1	.0876	.0869	.08708	.5469E-06
		2	.0861	.0877		
5	IT 1	1	.0850	.0850	.08500	.6667E-06
		2	.0860	.0840		
6	IT 2	1	.0780	.0770	.07788	.3729E-05
		2	.0760	.0805		
7	JP 1	1	.0815	.0824	.08063	.2802E-05
		2	.0800	.0786		
8	JP 2	1	.0873	.0903	.08800	.2460E-05
		2	.0868	.0876		
9	JP 3	1	.0873	.0885	.08765	.3300E-06
		2	.0873	.0875		
10	JP 5	1	.0865	.0900	.08818	.2856E-05
		2	.0870	.0892		
11	JP 6	1	.0819	.0825	.08238	.1825E-06
		2	.0829	.0822		
12	NL 1	1	.0863	.0852	.08590	.3133E-06
		2	.0864	.0857		
13	SU 1	1	.0860	.0845	.08505	.4700E-06
		2	.0851	.0846		
14	SU 3	1	.0861	.0858	.08543	.4092E-06
		2	.0847	.0851		

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-14 NICKEL WT %

COCHRAN'S TEST FOR BOTTLE VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

DOORNBOS' TEST FOR BOTTLE MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR TWO-WAY ANOVA

AU 2	ZERO WITHIN-BOTTLE VARIANCE
IT 1	ZERO WITHIN-BOTTLE VARIANCE

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-14 NICKEL WT %

TWO-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	11	.61355227E-03	.55777479E-04
BETWEEN BOTTLES	12	.20932325E-04	.17443604E-05
WITHIN BOTTLES	24	.31556450E-04	.13148521E-05
TOTAL	47	.66604105E-03	

F-CALC = 1.327 F-CRIT(.95;12,24) = 2.183

TEST SAMPLE IS HOMOGENEOUS

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-14 NICKEL WT %

COCHRAN'S TEST FOR LABORATORY VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

GRUBBS' TEST FOR LABORATORY MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR ONE-WAY ANOVA

ALL RESULTS WERE USED EXCEPT INDIVIDUAL REPLICATES LISTED BELOW

LIST OF INDIVIDUAL OUTLIERS DETECTED BY DIXON'S TEST WITHIN-LABORATORIES

NONE REJECTED

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-14 NICKEL WT %

ONE-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	13	.62819254E-03	.48322503E-04
WITHIN LABS	42	.56648775E-04	.13487804E-05
TOTAL	55	.68484131E-03	

REPEATABILITY VARIANCE	.13487804E-05
REPEATABILITY STD. DEV.	.00116137
BETWEEN-LABORATORIES VARIANCE	.11743431E-04
BETWEEN-LABORATORIES STD. DEV.	.00342687
REPEATABILITY	.00328668
PERMISSIBLE TOLERANCE BETWEEN LABS	.00997262
GRAND MEAN	.08433625
VARIANCE OF THE GRAND MEAN	.86290184E-06

ISO/TC 102/SC 2/WG 21B
IRON ORES - DETERMINATION OF NICKEL AND/OR CHROMIUM CONTENT
BY FLAME ATOMIC ABSORPTION METHOD

STATISTICAL REEVALUATION OF INTERNATIONAL TEST DATA - 1986

Appendix A. Cr

Detailed Computation of Analytical Data

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 79-6 CHROMIUM WT %

LABORATORY NO.	COUNTRY	BOTTLE NO.	ANALYTICAL RESULTS CHROMIUM		LAB MEAN	LAB VARIANCE
1	AU 1	1	.0032	.0035	.00322	.4687E-07
		2	.0030	.0033		
2	AU 2	1	.0039	.0037	.00380	.1333E-07
		2	.0037	.0039		
3	FR 1	1	.0033	.0035	.00348	.2917E-07
		2	.0034	.0037		
4	FR 2	1	.0039	.0038	.00393	.9167E-08
		2	.0040	.0040		
5	IT 1	1	.0050	.0045	.00388	.1063E-05
		2	.0030	.0030		
6	IT 2	1	.0048	.0050	.00458	.1892E-06
		2	.0040	.0045		
7	JP 1	1	.0031	.0031	.00325	.3667E-07
		2	.0035	.0033		
8	JP 2	1	.0034	.0034	.00338	.2500E-08
		2	.0033	.0034		
9	JP 3	1	.0034	.0032	.00328	.9167E-08
		2	.0033	.0032		
10	JP 5	1	.0035	.0038	.00364	.1489E-07
		2	.0037	.0037		
11	JP 6	1	.0037	.0035	.00360	.1333E-07
		2	.0035	.0037		
12	NL 1	1	.0034	.0032	.00328	.9167E-08
		2	.0033	.0032		
13	SU 1	1	.0038	.0040	.00393	.9167E-08
		2	.0039	.0040		
14	SU 2	1	.0035	.0028	.00315	.1633E-06
		2	.0035	.0028		
15	SU 3	1	.0033	.0029	.00310	.1933E-06
		2	.0036	.0026		

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 79-6 CHROMIUM WT %

COCHRAN'S TEST FOR BOTTLE VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

DOORNBOS' TEST FOR BOTTLE MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR TWO-WAY ANOVA

FR 2	ZERO WITHIN-BOTTLE VARIANCE
IT 1	ZERO WITHIN-BOTTLE VARIANCE
JP 1	ZERO WITHIN-BOTTLE VARIANCE
JP 2	ZERO WITHIN-BOTTLE VARIANCE

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 79-6 CHROMIUM WT %

TWO-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	10	.75722682E-05	.75722682E-06
BETWEEN BOTTLES	11	.50082500E-06	.45529545E-07
WITHIN BOTTLES	22	.15719500E-05	.71452273E-07
TOTAL	43	.96450432E-05	

F-CALC = .637 F-CRIT(.95;11,22) = 2.259

TEST SAMPLE IS HOMOGENEOUS

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 79-6 CHROMIUM WT %

COCHRAN'S TEST FOR LABORATORY VARIANCE (ALPHA=.01)

IT 1 C-CALC = .590 C-CRIT(4,15) = .332

STRAGGLERS (ALPHA =.05)

NONE

GRUBBS' TEST FOR LABORATORY MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR ONE-WAY ANOVA

IT 1 COCHRAN'S TEST FOR LABORATORY VARIANCE

LIST OF INDIVIDUAL OUTLIERS DETECTED BY DIXON'S TEST WITHIN-LABORATORIES

NONE REJECTED

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 79-6 CHROMIUM WT %

ONE-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	13	.86137089E-05	.66259299E-06
WITHIN LABS	42	.22177750E-05	.52804167E-07
TOTAL	55	.10831484E-04	

REPEATABILITY VARIANCE	.52804167E-07
REPEATABILITY STD. DEV.	.00022979
BETWEEN-LABORATORIES VARIANCE	.15244721E-06
BETWEEN-LABORATORIES STD. DEV.	.00039044
REPEATABILITY	.00065031
PERMISSIBLE TOLERANCE BETWEEN LABS	.00119682
GRAND MEAN	.00354196
VARIANCE OF THE GRAND MEAN	.11832018E-07

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 76-17 CHROMIUM WT %

LABORATORY NO.	COUNTRY	BOTTLE NO.	ANALYTICAL RESULTS CHROMIUM		LAB MEAN	LAB VARIANCE
1	AU 1	1	.0094	.0110	.01005	.4434E-06
		2	.0098	.0101		
2	AU 2	1	.0106	.0116	.01103	.2558E-06
		2	.0106	.0113		
3	FR 1	1	.0114	.0115	.01148	.2500E-08
		2	.0115	.0115		
4	FR 2	1	.0113	.0112	.01143	.1025E-06
		2	.0113	.0119		
5	IT 1	1	.0125	.0125	.01213	.2292E-06
		2	.0120	.0115		
6	IT 2	1	.0125	.0115	.01163	.3958E-06
		2	.0115	.0110		
7	JP 1	1	.0118	.0120	.01123	.6158E-06
		2	.0106	.0105		
8	JP 2	1	.0119	.0111	.01155	.1167E-06
		2	.0115	.0117		
9	JP 3	1	.0115	.0115	.01153	.2500E-08
		2	.0116	.0115		
10	JP 5	1	.0113	.0117	.01163	.1825E-06
		2	.0113	.0122		
11	JP 6	1	.0120	.0114	.01138	.2025E-06
		2	.0111	.0110		
12	NL 1	1	.0112	.0114	.01115	.3667E-07
		2	.0110	.0110		
13	SU 1	1	.0123	.0117	.01193	.8250E-07
		2	.0120	.0117		
14	SU 2	1	.0128	.0104	.01160	.1920E-05
		2	.0128	.0104		
15	SU 3	1	.0109	.0114	.01178	.2269E-05
		2	.0108	.0140		

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 76-17 CHROMIUM WT %

COCHRAN'S TEST FOR BOTTLE VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

DOORNBOS' TEST FOR BOTTLE MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR TWO-WAY ANOVA

FR 1	ZERO WITHIN-BOTTLE VARIANCE
IT 1	ZERO WITHIN-BOTTLE VARIANCE
JP 3	ZERO WITHIN-BOTTLE VARIANCE
NL 1	ZERO WITHIN-BOTTLE VARIANCE

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 76-17 CHROMIUM WT %

TWO-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	10	.10312114E-04	.10312114E-05
BETWEEN BOTTLES	11	.46606250E-05	.42369318E-06
WITHIN BOTTLES	22	.15099450E-04	.68633864E-06
TOTAL	43	.30072189E-04	

F-CALC = .617 F-CRIT(.95;11,22) = 2.259

TEST SAMPLE IS HOMOGENEOUS

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 76-17 CHROMIUM WT %

COCHRAN'S TEST FOR LABORATORY VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

SU 3 C-CALC = .331 C-CRIT(4,15) = .276

SU 2 C-CALC = .418 C-CRIT(4,14) = .291

GRUBBS' TEST FOR LABORATORY MEANS (ALPHA=.01)

AU 1 T = 2.906 T-CRIT(15) = 2.806

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR ONE-WAY ANOVA

AU 1 GRUBBS' TEST FOR LABORATORY MEANS

LIST OF INDIVIDUAL OUTLIERS DETECTED BY DIXON'S TEST WITHIN-LABORATORIES

NONE REJECTED

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 76-17 CHROMIUM WT %

ONE-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	13	.44958929E-05	.34583791E-06
WITHIN LABS	42	.19242500E-04	.45815476E-06
TOTAL	55	.23738393E-04	

REPEATABILITY VARIANCE	.45815476E-06
REPEATABILITY STD. DEV.	.00067687
BETWEEN-LABORATORIES VARIANCE	.00000000E+00
BETWEEN-LABORATORIES STD. DEV.	.00000000
REPEATABILITY	.00191555
PERMISSIBLE TOLERANCE BETWEEN LABS	.00135450
GRAND MEAN	.01153036
VARIANCE OF THE GRAND MEAN	.81813350E-08

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 81-6 CHROMIUM WT %

LABORATORY NO.	COUNTRY	BOTTLE NO.	ANALYTICAL RESULTS CHROMIUM		LAB MEAN	LAB VARIANCE
1	AU 1	1	.0540	.0510	.05201	.1822E-05
		2	.0517	.0513		
2	AU 2	1	.0575	.0575	.05725	.8333E-07
		2	.0570	.0570		
3	FR 1	1	.0570	.0560	.05650	.3333E-06
		2	.0570	.0560		
4	FR 2	1	.0585	.0589	.05828	.2692E-06
		2	.0579	.0578		
5	IT 1	1	.0525	.0530	.05263	.2292E-06
		2	.0530	.0520		
6	IT 2	1	.0520	.0550	.05325	.4250E-05
		2	.0550	.0510		
7	JP 1	1	.0543	.0535	.05438	.4092E-06
		2	.0549	.0548		
8	JP 2	1	.0571	.0582	.05788	.3758E-06
		2	.0585	.0577		
9	JP 3	1	.0538	.0557	.05518	.9025E-06
		2	.0553	.0559		
10	JP 5	1	.0567	.0608	.05868	.4116E-05
		2	.0572	.0600		
11	JP 6	1	.0557	.0571	.05598	.1449E-05
		2	.0544	.0567		
12	NL 1	1	.0555	.0560	.05488	.2022E-05
		2	.0552	.0528		
13	SU 1	1	.0570	.0569	.05683	.2917E-07
		2	.0566	.0568		
14	SU 2	1	.0591	.0560	.05750	.3647E-05
		2	.0592	.0557		
15	SU 3	1	.0564	.0568	.05673	.4917E-07
		2	.0569	.0568		

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 81-6 CHROMIUM WT %

COCHRAN'S TEST FOR BOTTLE VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

DOORNBOS' TEST FOR BOTTLE MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR TWO-WAY ANOVA

AU 2 ZERO WITHIN-BOTTLE VARIANCE

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 81-6 CHROMIUM WT %

TWO-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	13	.23279308E-03	.17907160E-04
BETWEEN BOTTLES	14	.78352250E-05	.55965893E-06
WITHIN BOTTLES	28	.51875250E-04	.18526875E-05
TOTAL	55	.29250356E-03	

F-CALC = .302 F-CRIT(.95;14,28) = 2.064

TEST SAMPLE IS HOMOGENEOUS

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 81-6 CHROMIUM WT %

COCHRAN'S TEST FOR LABORATORY VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

GRUBBS' TEST FOR LABORATORY MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR ONE-WAY ANOVA

ALL RESULTS WERE USED EXCEPT INDIVIDUAL REPLICATES LISTED BELOW

LIST OF INDIVIDUAL OUTLIERS DETECTED BY DIXON'S TEST WITHIN-LABORATORIES

NONE REJECTED

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 81-6 CHROMIUM WT %

ONE-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	14	.24106358E-03	.17218827E-04
WITHIN LABS	45	.59960475E-04	.13324550E-05
TOTAL	59	.30102406E-03	

REPEATABILITY VARIANCE	.13324550E-05
REPEATABILITY STD. DEV.	.00115432
BETWEEN-LABORATORIES VARIANCE	.39715931E-05
BETWEEN-LABORATORIES STD. DEV.	.00199289
REPEATABILITY	.00326673
PERMISSIBLE TOLERANCE BETWEEN LABS	.00609457
GRAND MEAN	.05586083
VARIANCE OF THE GRAND MEAN	.28698046E-06

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-13 CHROMIUM WT %

LABORATORY NO.	COUNTRY	BOTTLE NO.	ANALYTICAL RESULTS CHROMIUM		LAB MEAN	LAB VARIANCE
1	AU 1	1	.0151	.0156	.01512	.1217E-06
		2	.0148	.0150		
2	AU 2	1	.0162	.0164	.01620	.2667E-07
		2	.0160	.0162		
3	FR 1	1	.0165	.0156	.01598	.2492E-06
		2	.0163	.0155		
4	FR 2	1	.0165	.0170	.01695	.9667E-07
		2	.0172	.0171		
5	IT 1	1	.0170	.0170	.01650	.3333E-06
		2	.0160	.0160		
6	IT 2	1	.0175	.0170	.01675	.7500E-06
		2	.0170	.0155		
7	JP 1	1	.0160	.0156	.01553	.1292E-06
		2	.0152	.0153		
8	JP 2	1	.0172	.0169	.01685	.8333E-07
		2	.0168	.0165		
9	JP 3	1	.0162	.0167	.01638	.1092E-06
		2	.0160	.0166		
10	JP 5	1	.0167	.0172	.01683	.8917E-07
		2	.0165	.0169		
11	JP 6	1	.0161	.0161	.01615	.3000E-07
		2	.0164	.0160		
12	NL 1	1	.0161	.0159	.01595	.1667E-07
		2	.0160	.0158		
13	SU 1	1	.0171	.0177	.01745	.9000E-07
		2	.0173	.0177		
14	SU 2	1	.0168	.0155	.01613	.5225E-06
		2	.0167	.0155		
15	SU 3	1	.0165	.0163	.01648	.5583E-07
		2	.0163	.0168		

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-13 CHROMIUM WT %

COCHRAN'S TEST FOR BOTTLE VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

DOORNBOS' TEST FOR BOTTLE MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR TWO-WAY ANOVA

IT 1	ZERO WITHIN-BOTTLE VARIANCE
JP 6	ZERO WITHIN-BOTTLE VARIANCE

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-13 CHROMIUM WT %

TWO-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	12	.19156477E-04	.15963731E-05
BETWEEN BOTTLES	13	.20175000E-05	.15519231E-06
WITHIN BOTTLES	26	.50025000E-05	.19240385E-06
TOTAL	51	.26176477E-04	

F-CALC = .807 F-CRIT(.95;13,26) = 2.119

TEST SAMPLE IS HOMOGENEOUS

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-13 CHROMIUM WT %

COCHRAN'S TEST FOR LABORATORY VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

IT 2 C-CALC = .277 C-CRIT(4,15) = .276

GRUBBS' TEST FOR LABORATORY MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR ONE-WAY ANOVA

ALL RESULTS WERE USED EXCEPT INDIVIDUAL REPLICATES LISTED BELOW

LIST OF INDIVIDUAL OUTLIERS DETECTED BY DIXON'S TEST WITHIN-LABORATORIES

NONE REJECTED

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-13 CHROMIUM WT %

ONE-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	14	.19406360E-04	.13861686E-05
WITHIN LABS	45	.81100000E-05	.18022222E-06
TOTAL	59	.27516360E-04	

REPEATABILITY VARIANCE	.18022222E-06
REPEATABILITY STD. DEV.	.00042453
BETWEEN-LABORATORIES VARIANCE	.30148659E-06
BETWEEN-LABORATORIES STD. DEV.	.00054908
REPEATABILITY	.00120141
PERMISSIBLE TOLERANCE BETWEEN LABS	.00177095
GRAND MEAN	.01634800
VARIANCE OF THE GRAND MEAN	.23102810E-07

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-14 CHROMIUM WT %

LABORATORY NO.	COUNTRY	BOTTLE NO.	ANALYTICAL RESULTS CHROMIUM		LAB MEAN	LAB VARIANCE
1	AU 1	1	.0161	.0174	.01658	.5362E-06
		2	.0159	.0169		
2	AU 2	1	.0181	.0181	.01855	.8100E-06
		2	.0199	.0181		
3	FR 1	1	.0185	.0195	.01893	.2558E-06
		2	.0185	.0192		
4	FR 2	1	.0191	.0184	.01878	.1425E-06
		2	.0185	.0191		
5	IT 1	1	.0200	.0205	.01975	.4167E-06
		2	.0190	.0195		
6	IT 2	1	.0190	.0205	.02050	.1500E-05
		2	.0220	.0205		
7	JP 1	1	.0190	.0185	.01843	.1892E-06
		2	.0180	.0182		
8	JP 2	1	.0190	.0188	.01875	.1433E-06
		2	.0190	.0182		
9	JP 3	1	.0190	.0178	.01825	.2967E-06
		2	.0183	.0179		
10	JP 5	1	.0184	.0185	.01855	.1667E-07
		2	.0186	.0187		
11	JP 6	1	.0184	.0183	.01815	.1367E-06
		2	.0176	.0183		
12	NL 1	1	.0182	.0178	.01785	.5667E-07
		2	.0177	.0177		
13	SU 1	1	.0187	.0190	.01903	.1158E-06
		2	.0195	.0189		
14	SU 2	1	.0188	.0178	.01828	.3692E-06
		2	.0188	.0177		
15	SU 3	1	.0185	.0182	.01845	.3100E-06
		2	.0179	.0192		

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-14 CHROMIUM WT %

COCHRAN'S TEST FOR BOTTLE VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

DOORNBOS' TEST FOR BOTTLE MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

IT 2 BOTTLE- 2 T-CALC = 3.572 T-CRIT(.00167,28) = 3.479

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR TWO-WAY ANOVA

AU 2 ZERO WITHIN-BOTTLE VARIANCE
NL 1 ZERO WITHIN-BOTTLE VARIANCE

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-14 CHROMIUM WT %

TWO-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	12	.39241477E-04	.32701231E-05
BETWEEN BOTTLES	13	.43581000E-05	.33523846E-06
WITHIN BOTTLES	26	.89280000E-05	.34338462E-06
TOTAL	51	.52527577E-04	

F-CALC = .976 F-CRIT(.95;13,26) = 2.119

TEST SAMPLE IS HOMOGENEOUS

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-14 CHROMIUM WT %

COCHRAN'S TEST FOR LABORATORY VARIANCE (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

IT 2 C-CALC = .283 C-CRIT(4,15) = .276

GRUBBS' TEST FOR LABORATORY MEANS (ALPHA=.01)

NONE REJECTED

STRAGGLERS (ALPHA =.05)

NONE

LIST OF LABORATORIES WHOSE RESULTS WERE NOT USED FOR ONE-WAY ANOVA

ALL RESULTS WERE USED EXCEPT INDIVIDUAL REPLICATES LISTED BELOW

LIST OF INDIVIDUAL OUTLIERS DETECTED BY DIXON'S TEST WITHIN-LABORATORIES

NONE REJECTED

ISO/TC 102/SC 2/WG 21B 1986 --- NI/CR BY FLAME AAS METHOD
SAMPLE: 85-14 CHROMIUM WT %

ONE-WAY ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARE
BETWEEN LABS	14	.41603960E-04	.29717114E-05
WITHIN LABS	45	.15886100E-04	.35302444E-06
TOTAL	59	.57490060E-04	

REPEATABILITY VARIANCE	.35302444E-06
REPEATABILITY STD. DEV.	.00059416
BETWEEN-LABORATORIES VARIANCE	.65467175E-06
BETWEEN-LABORATORIES STD. DEV.	.00080912
REPEATABILITY	.00168147
PERMISSIBLE TOLERANCE BETWEEN LABS	.00258009
GRAND MEAN	.01858700
VARIANCE OF THE GRAND MEAN	.49528524E-07